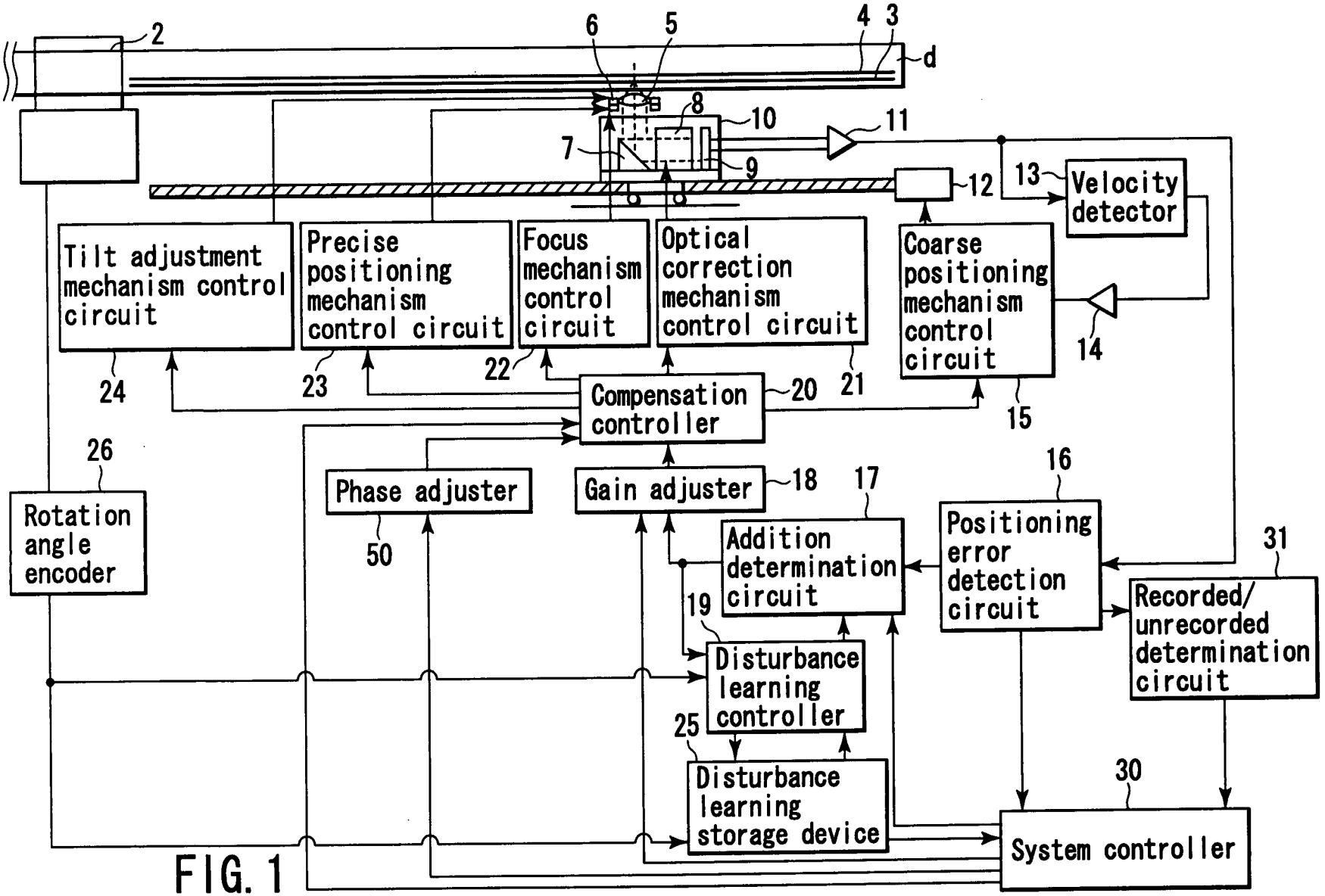

2
6
5
4
3
d
8
10
11
7
9
12
13
Velocity detector
Tilt adjustment mechanism control circuit
Precise positioning mechanism control circuit
Focus mechanism control circuit
Optical correction mechanism control circuit
Coarse positioning mechanism control circuit
14
24
23
22
21
Compensation controller
20
15
26
Phase adjuster
Gain adjuster
18
17
16
Rotation angle encoder
50
Addition determination circuit
Positioning error detection circuit
31
19
Recorded/ unrecorded determination circuit
Disturbance learning controller
25
Disturbance learning storage device
30
System controller

FIG. 1

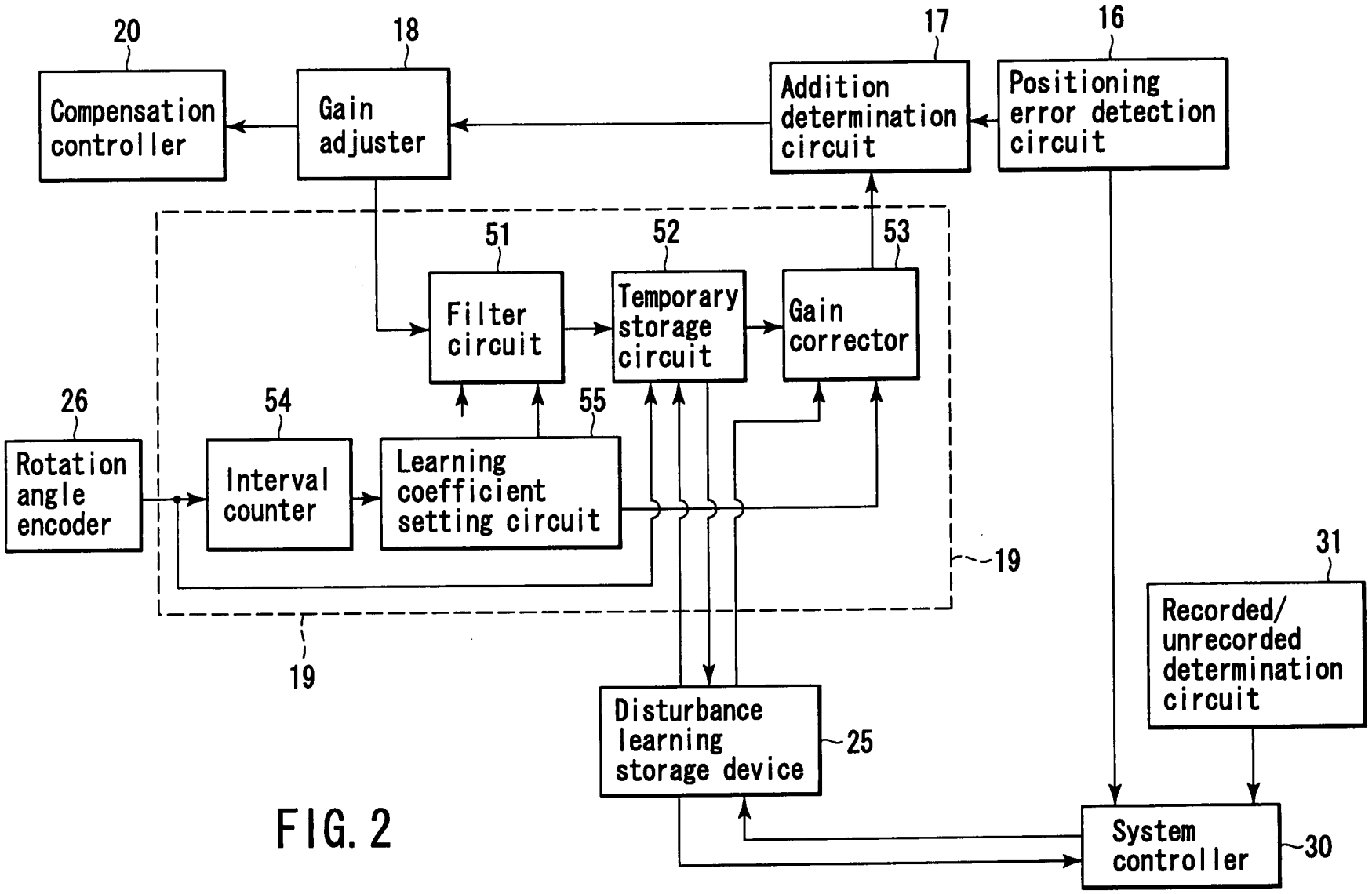

20
Compensation controller
18
Gain adjuster
17
Addition determination circuit
16
Positioning error detection circuit
51
Filter circuit
52
Temporary storage circuit
53
Gain corrector
26
Rotation angle encoder
54
Interval counter
55
Learning coefficient setting circuit
19
19
Disturbance learning storage device
25
31
Recorded/ unrecorded determination circuit
System controller
30

FIG. 2

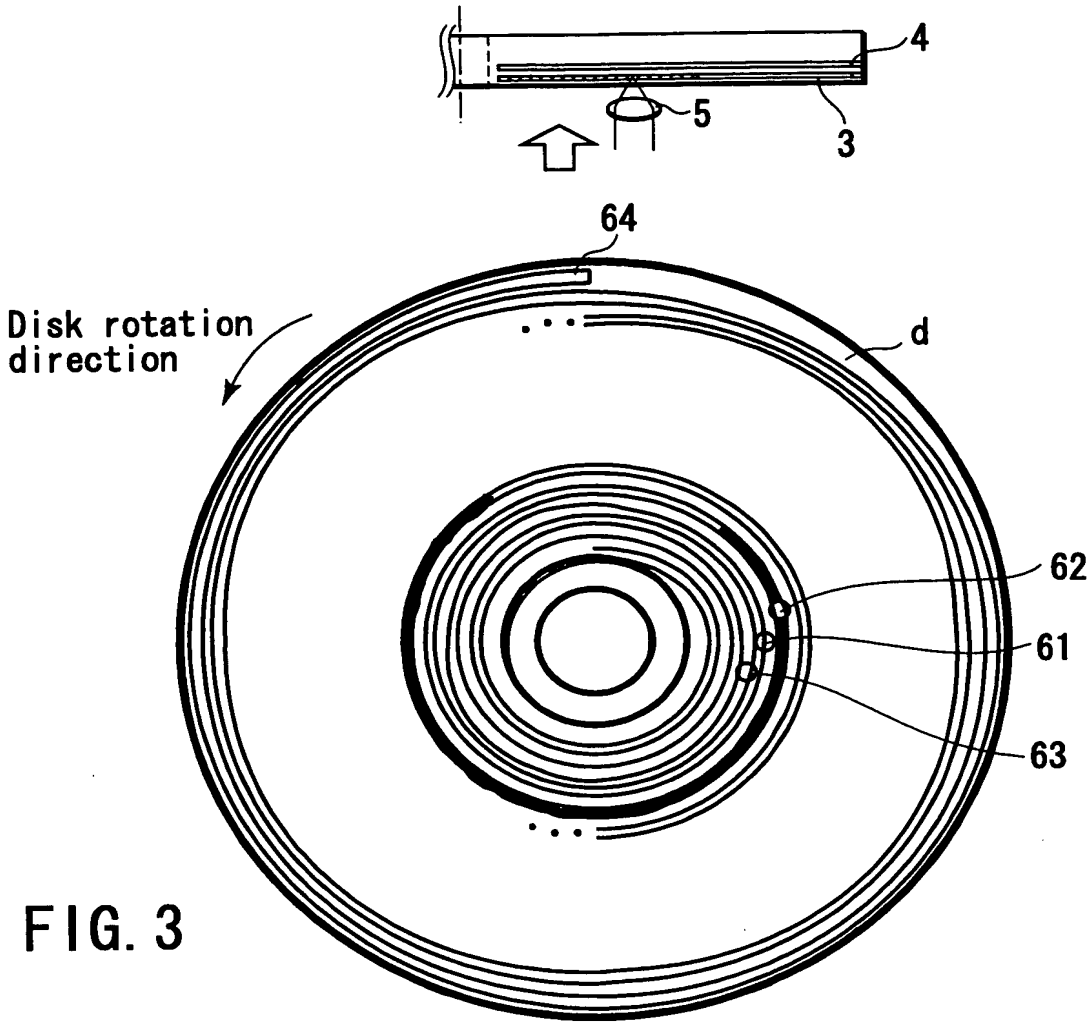



FIG. 3

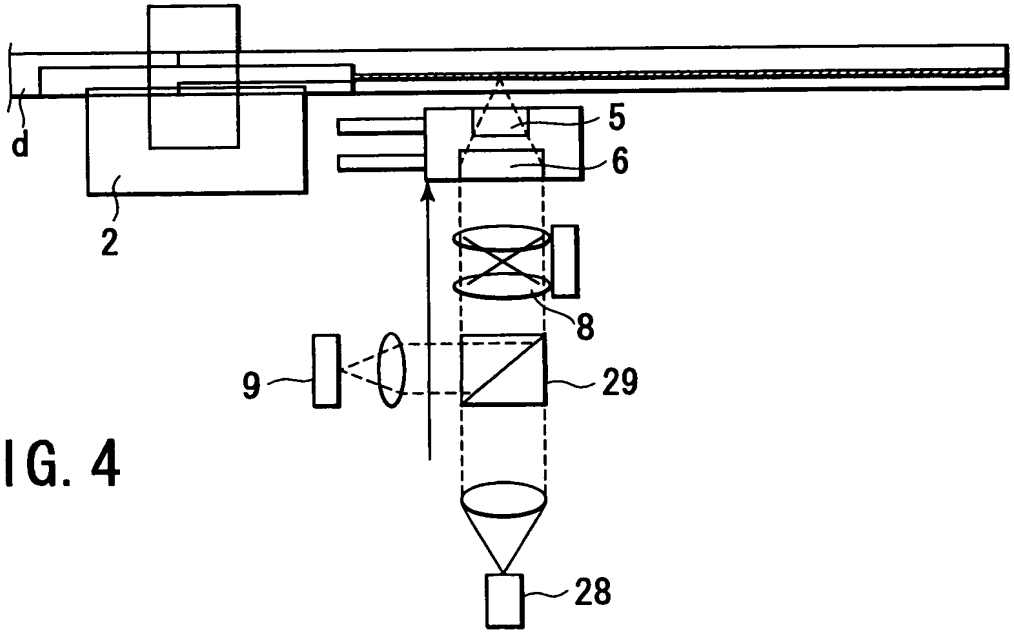



FIG. 4

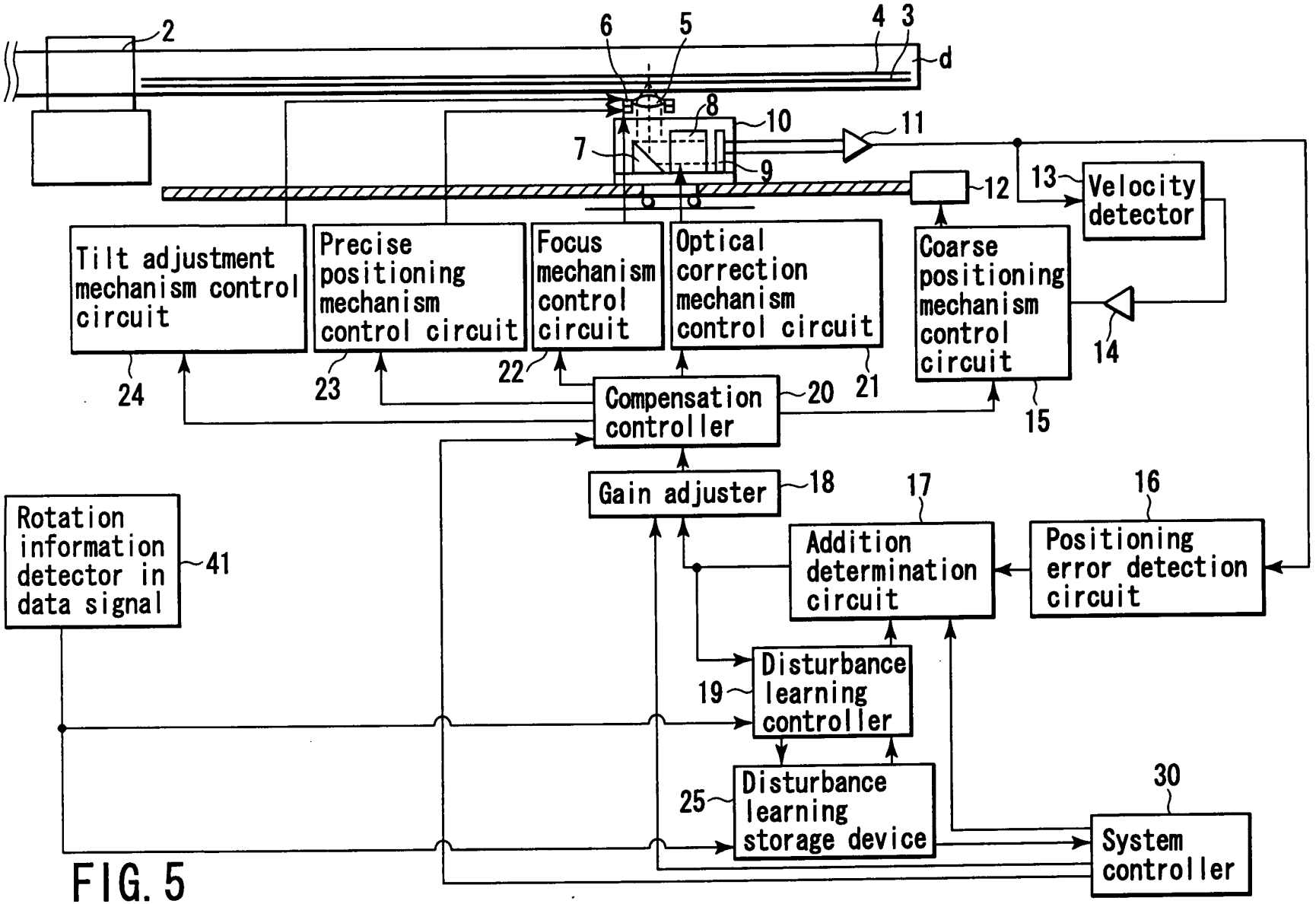

2
6
5
4
3
d
8
10
11
7
9
12
13
Velocity detector
Tilt adjustment mechanism control circuit
Precise positioning mechanism control circuit
Focus mechanism control circuit
Optical correction mechanism control circuit
Coarse positioning mechanism control circuit
14
24
23
22
21
Compensation controller
20
15
Gain adjuster
18
17
16
Rotation information detector in data signal
41
Addition determination circuit
Positioning error detection circuit
Disturbance learning controller
19
Disturbance learning storage device
25
30
System controller

FIG. 5

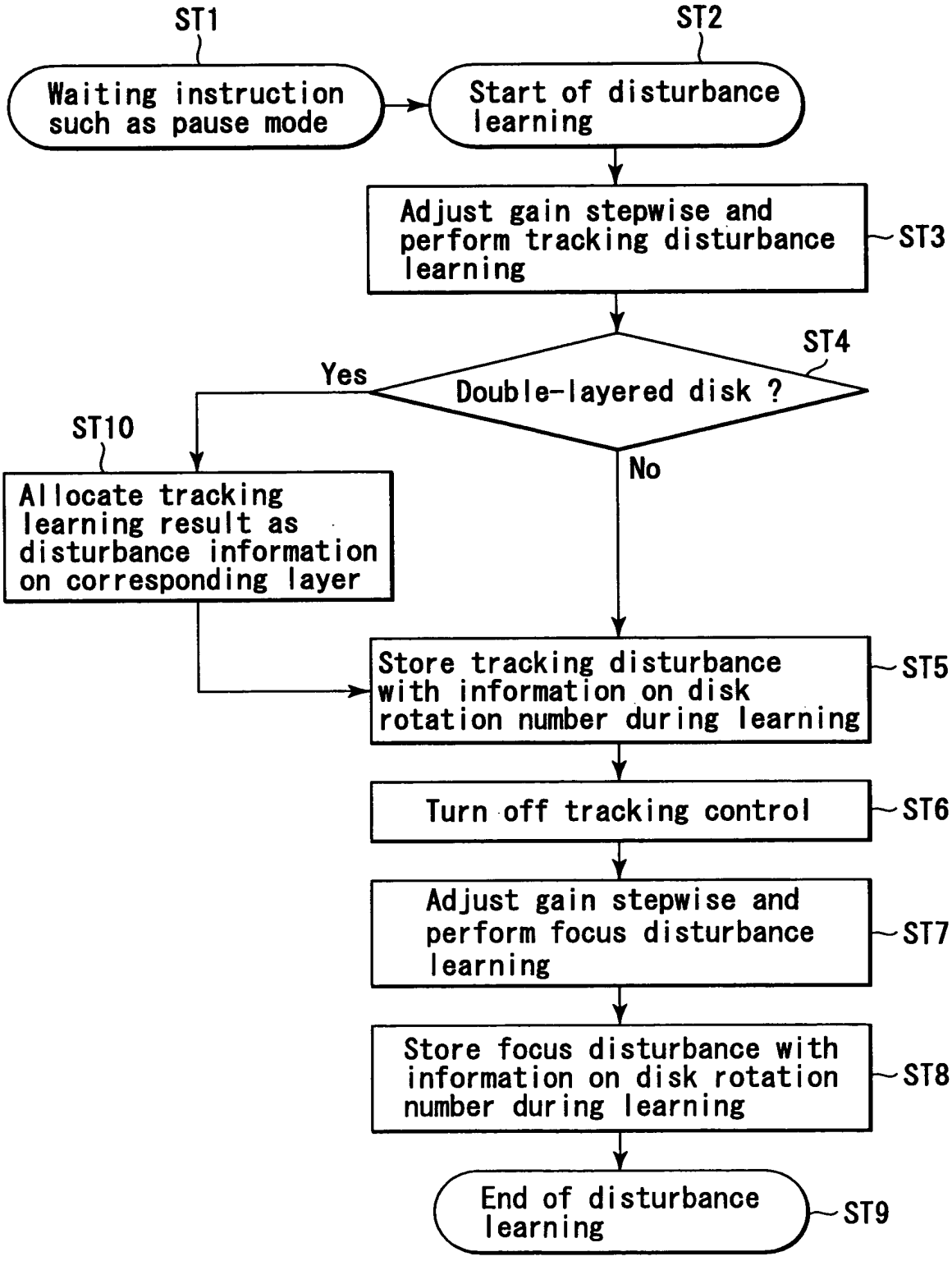

ST1
Waiting instruction such as pause mode
ST2
Start of disturbance learning
Adjust gain stepwise and perform tracking disturbance learning
ST3
ST4
Double-layered disk ?
Yes
No
ST10
Allocate tracking learning result as disturbance information on corresponding layer
Store tracking disturbance with information on disk rotation number during learning
ST5
Turn off tracking control
ST6
Adjust gain stepwise and perform focus disturbance learning
ST7
Store focus disturbance with information on disk rotation number during learning
ST8
End of disturbance learning
ST9

FIG. 6

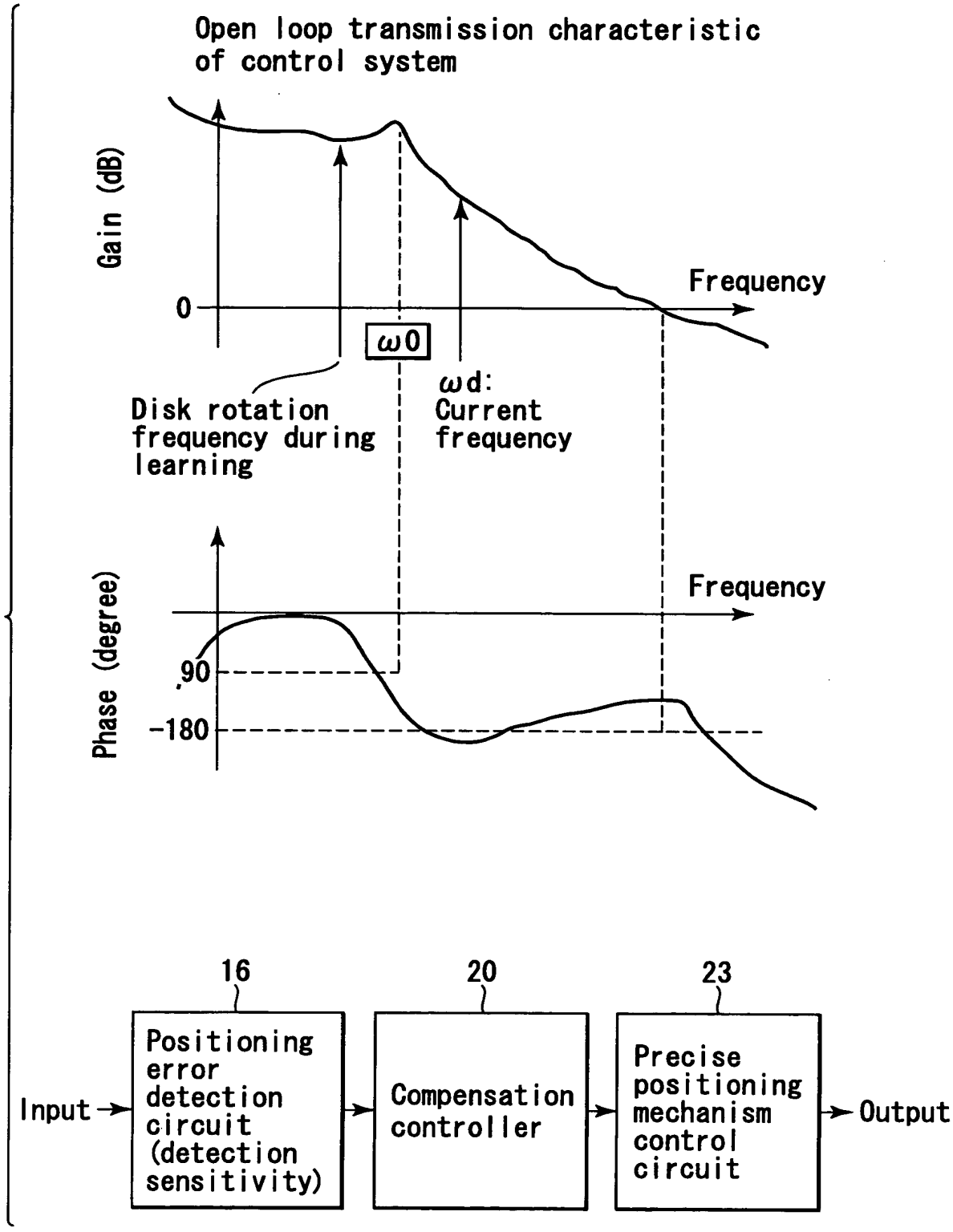

Open loop transmission characteristic of control system
Gain (dB)
0
Frequency
ω0
Disk rotation frequency during learning
ωd: Current frequency
Phase (degree)
Frequency
90
-180
16
20
23
Input
Positioning error detection circuit (detection sensitivity)
Compensation controller
Precise positioning mechanism control circuit
Output

FIG. 7

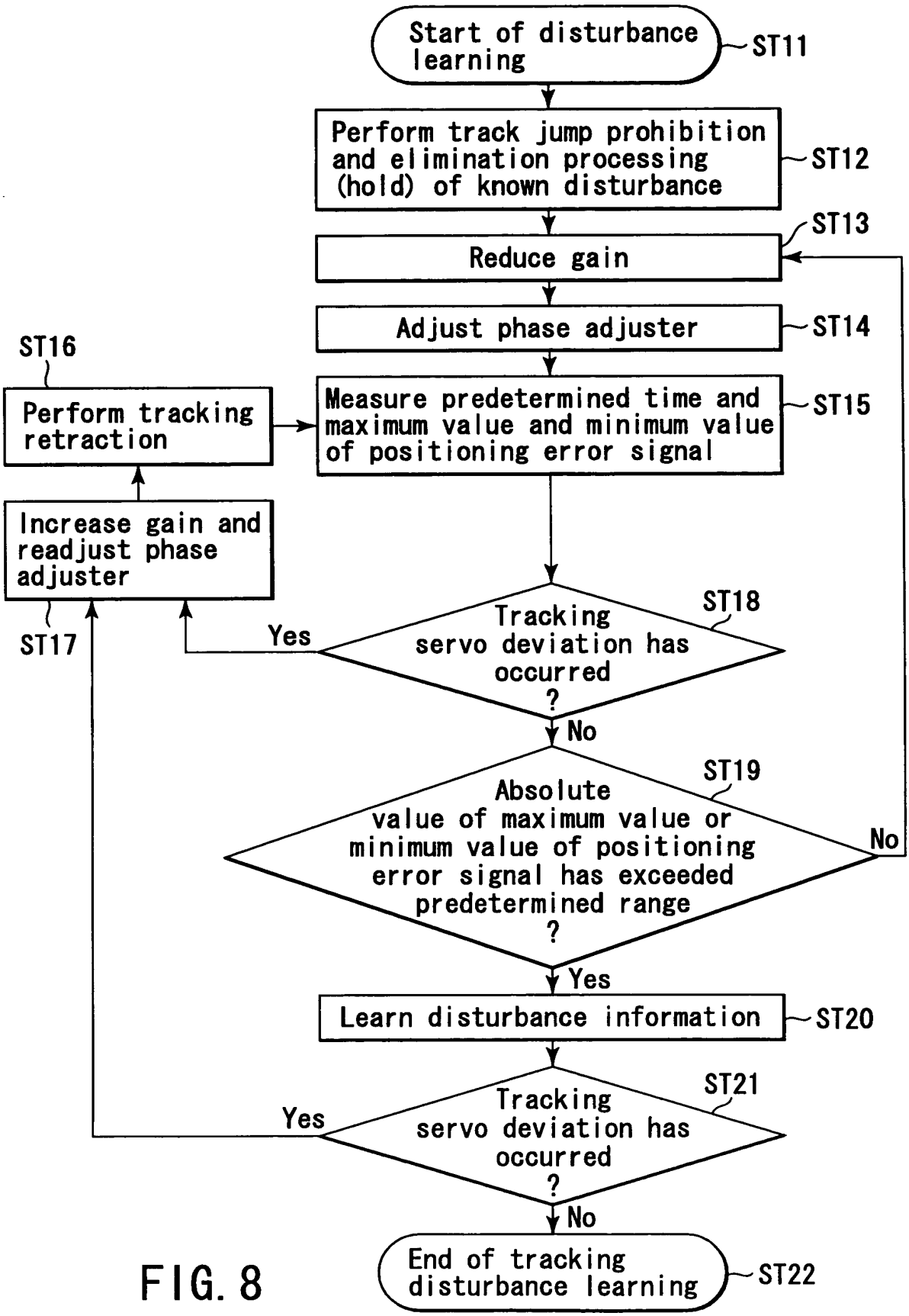

Start of disturbance learning
ST11
Perform track jump prohibition and elimination processing (hold) of known disturbance
ST12
Reduce gain
ST13
Adjust phase adjuster
ST14
Measure predetermined time and maximum value and minimum value of positioning error signal
ST15
Perform tracking retraction
ST16
Increase gain and readjust phase adjuster
ST17
Tracking servo deviation has occurred ?
ST18
Yes
No
Absolute value of maximum value or minimum value of positioning error signal has exceeded predetermined range ?
ST19
No
Yes
Learn disturbance information
ST20
Tracking servo deviation has occurred ?
ST21
Yes
No
End of tracking disturbance learning
ST22

FIG. 8

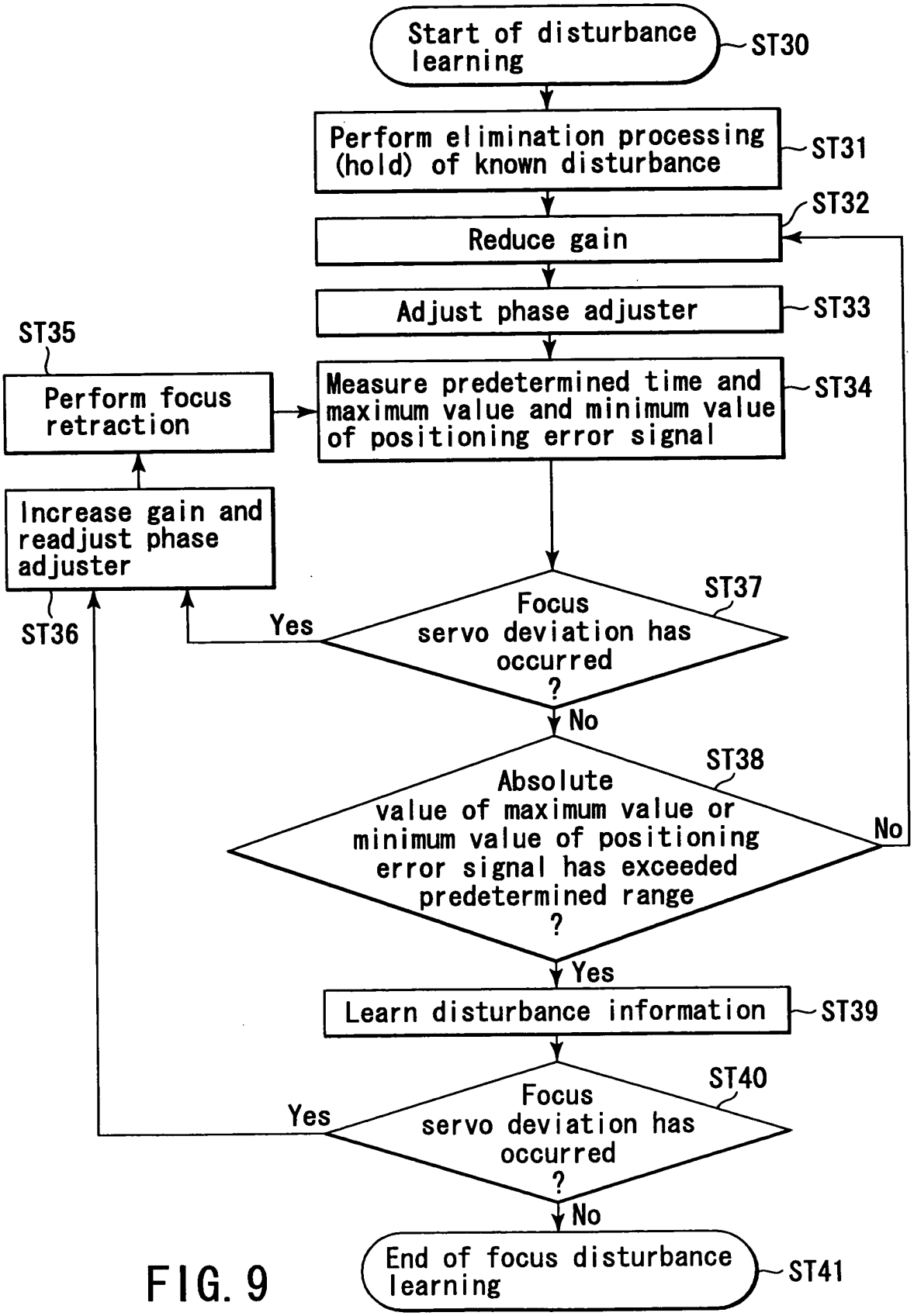

Start of disturbance learning
ST30
Perform elimination processing (hold) of known disturbance
ST31
ST32
Reduce gain
Adjust phase adjuster
ST33
ST35
Perform focus retraction
Measure predetermined time and maximum value and minimum value of positioning error signal
ST34
Increase gain and readjust phase adjuster
ST36
Yes
Focus servo deviation has occurred ?
ST37
No
ST38
Absolute value of maximum value or minimum value of positioning error signal has exceeded predetermined range ?
No
Yes
Learn disturbance information
ST39
ST40
Yes
Focus servo deviation has occurred ?
No
End of focus disturbance learning
ST41

FIG. 9

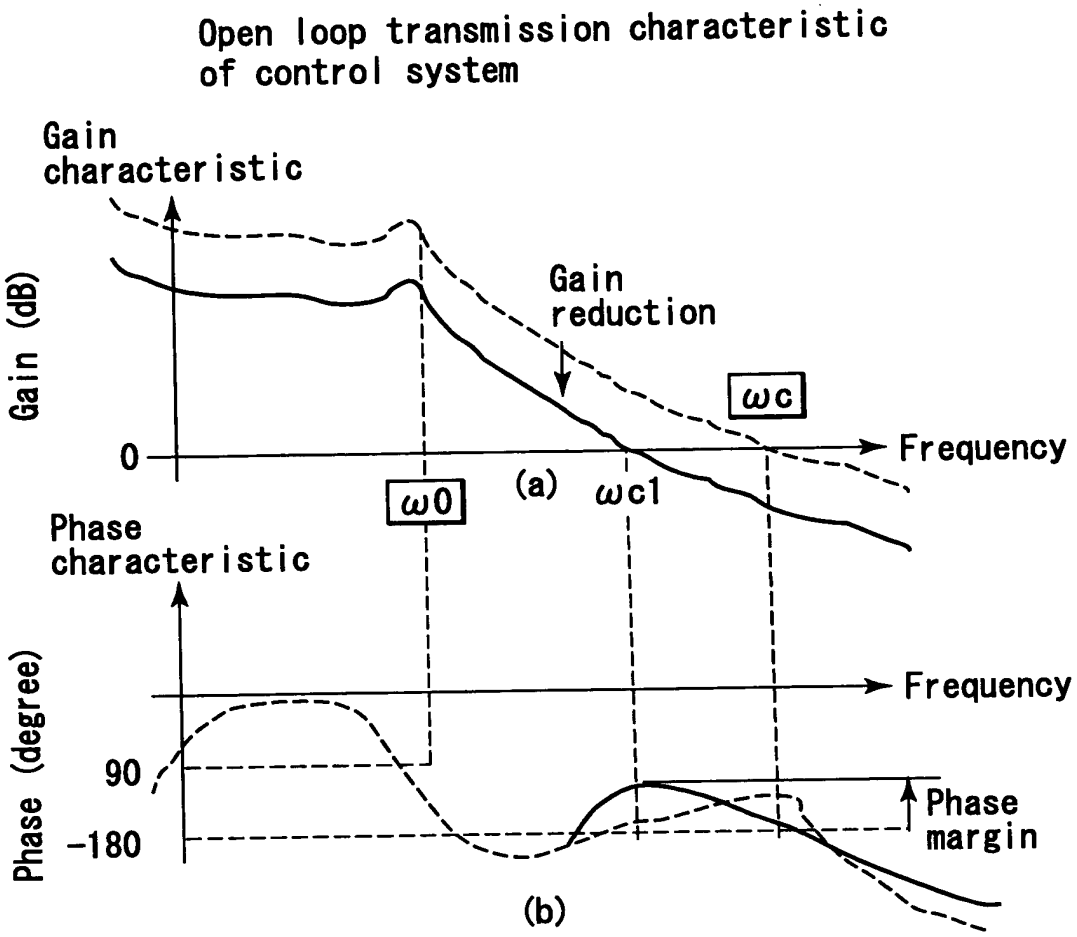

Open loop transmission characteristic of control system
Gain characteristic
Gain (dB)
Gain reduction
ωc
0
Frequency
ω0
(a)
ωc1
Phase characteristic
Phase (degree)
Frequency
90
-180
Phase margin
(b)

FIG. 10

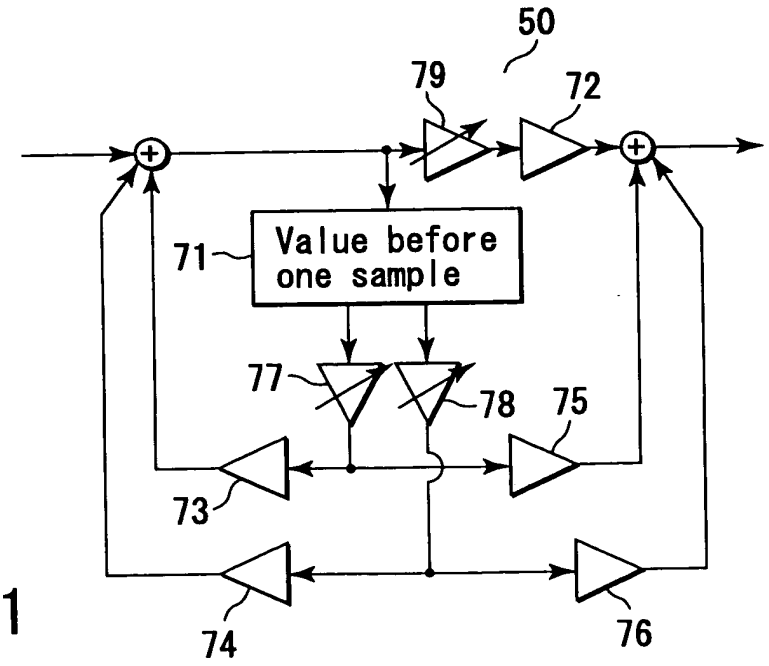
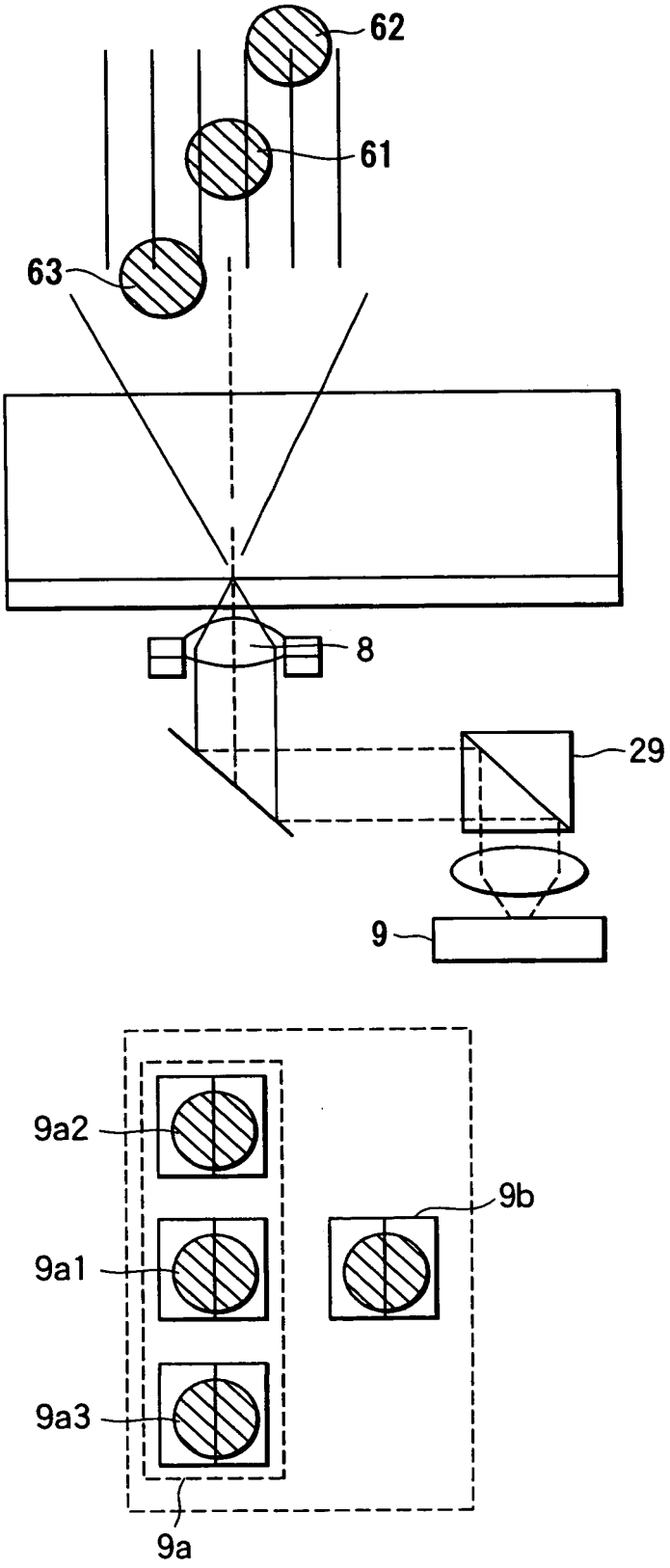
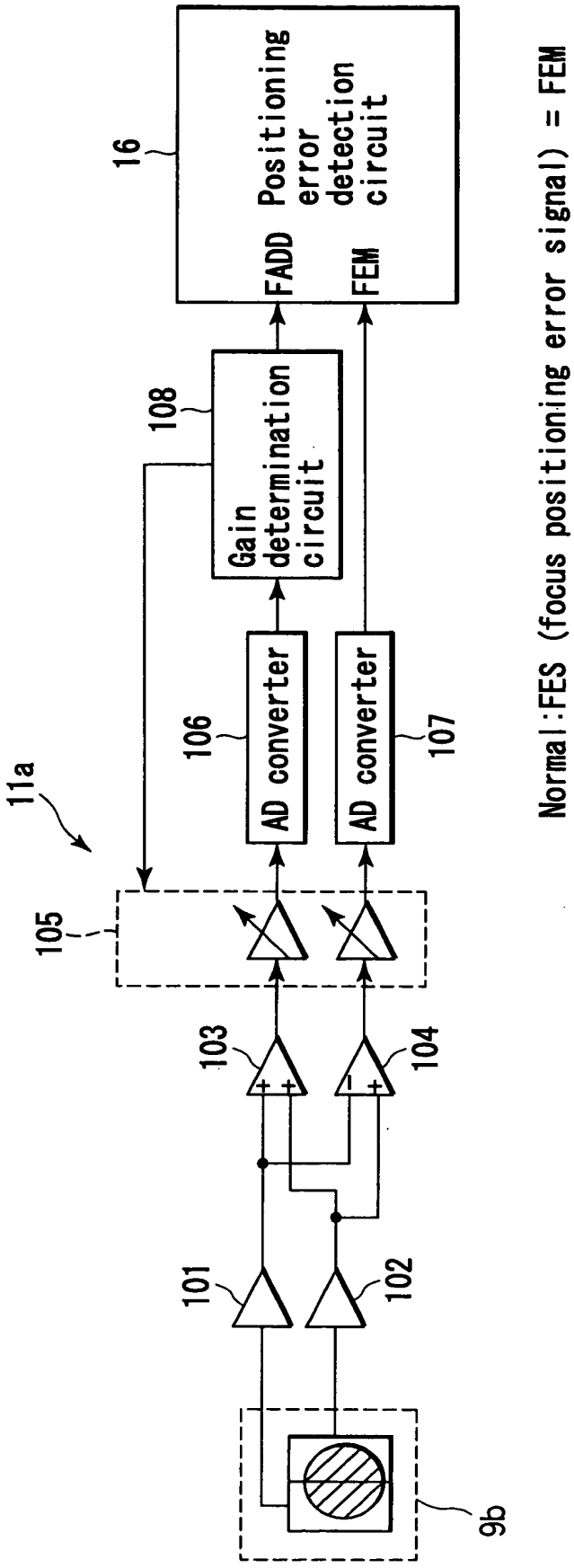

50
79
72
71
Value before one sample
77
78
75
73
74
76

FIG. 11

FIG. 12






Normal:FES (focus positioning error signal) = FEM

FIG. 13

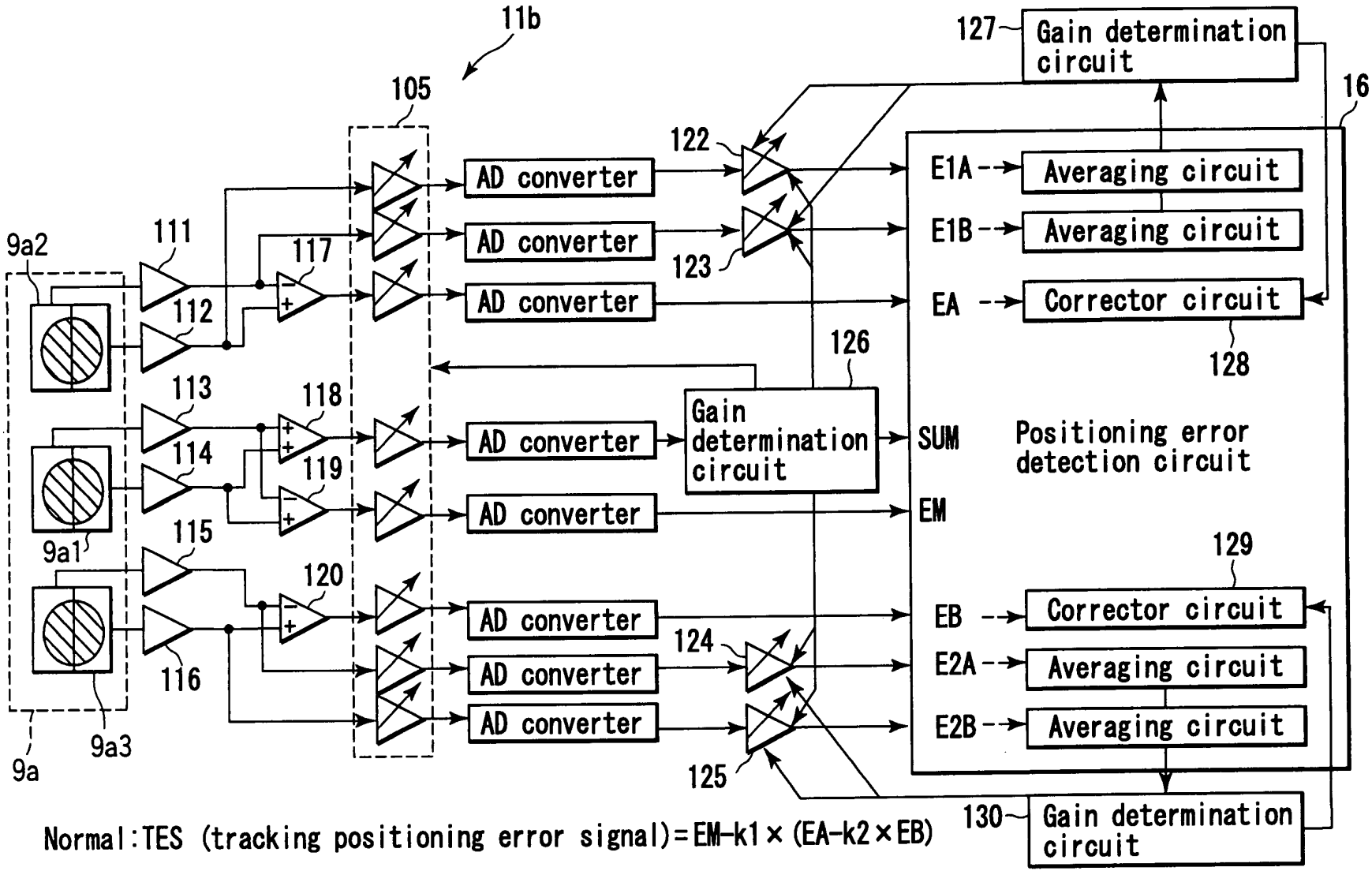

11b
105
127
Gain determination circuit
16
122
AD converter
AD converter
AD converter
E1A
Averaging circuit
E1B
Averaging circuit
EA
Corrector circuit
128
123
9a2
111
117
112
126
113
118
114
119
AD converter
AD converter
Gain determination circuit
SUM
Positioning error detection circuit
EM
9a1
115
120
129
AD converter
AD converter
AD converter
EB
Corrector circuit
E2A
Averaging circuit
E2B
Averaging circuit
124
116
9a
9a3
125
130
Gain determination circuit
Normal:TES (tracking positioning error signal)=EM-k1×(EA-k2×EB)

FIG. 14

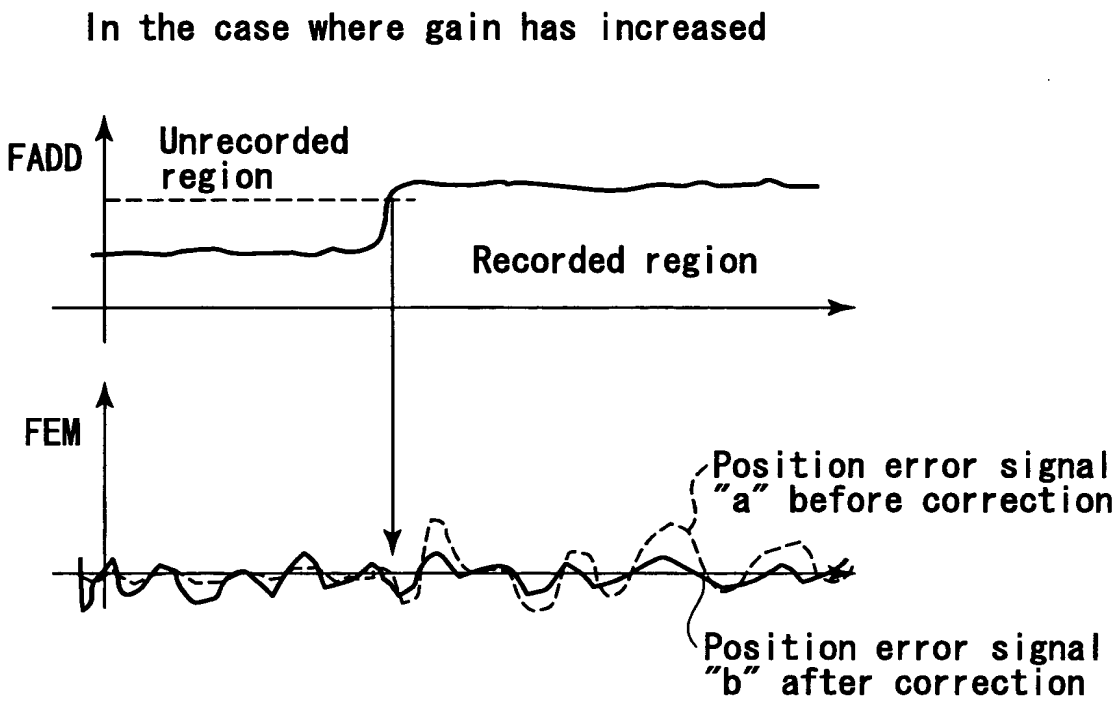
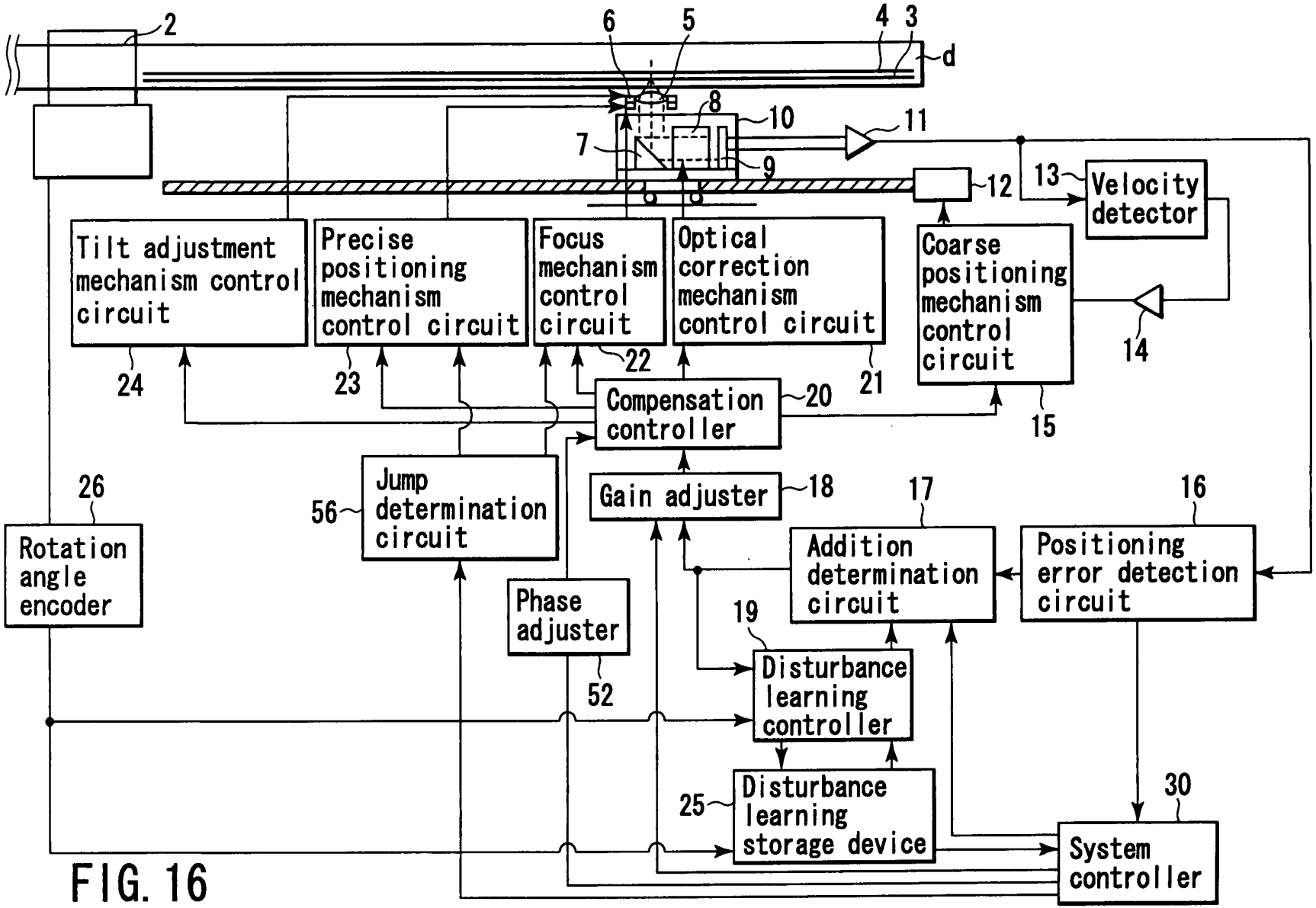

In the case where gain has increased
FADD
Unrecorded region
Recorded region
FEM
Position error signal "a" before correction
Position error signal "b" after correction

FIG. 15


2
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13
Velocity detector
Tilt adjustment mechanism control circuit
Precise positioning mechanism control circuit
Focus mechanism control circuit
Optical correction mechanism control circuit
Coarse positioning mechanism control circuit
14
24
23
22
21
Compensation controller
20
15
26
56
Jump determination circuit
Gain adjuster
18
17
16
Rotation angle encoder
Addition determination circuit
Positioning error detection circuit
Phase adjuster
19
Disturbance learning controller
52
25
Disturbance learning storage device
30
System controller

FIG. 16

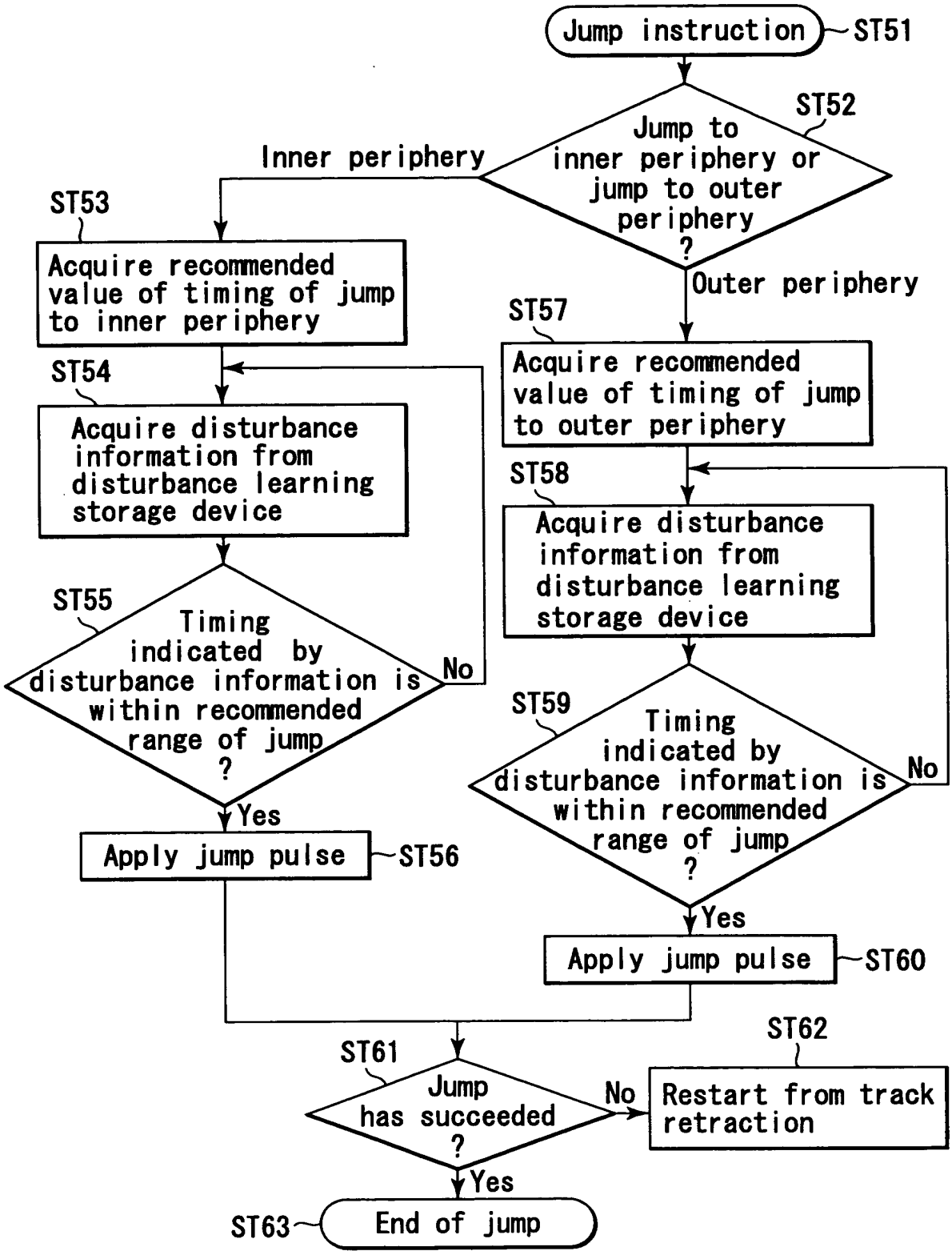
Jump instruction
ST51
ST52
Jump to inner periphery or jump to outer periphery ?
Inner periphery
Outer periphery
ST53
Acquire recommended value of timing of jump to inner periphery
ST54
Acquire disturbance information from disturbance learning storage device
ST55
Timing indicated by disturbance information is within recommended range of jump ?
No
Yes
Apply jump pulse
ST56
ST57
Acquire recommended value of timing of jump to outer periphery
ST58
Acquire disturbance information from disturbance learning storage device
ST59
Timing indicated by disturbance information is within recommended range of jump ?
No
Yes
Apply jump pulse
ST60
ST61
Jump has succeeded ?
No
ST62
Restart from track retraction
Yes
ST63
End of jump

FIG. 17

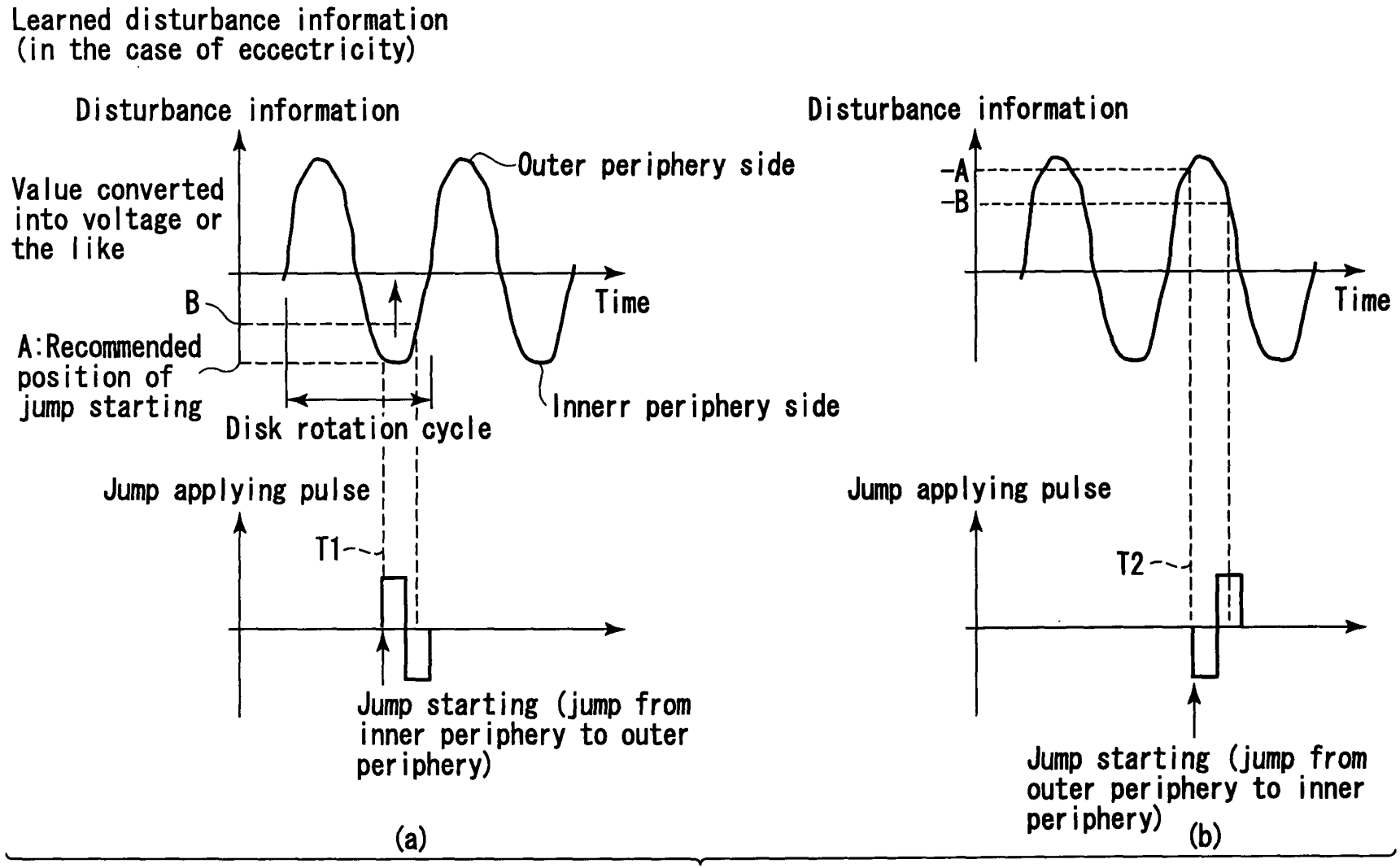
Learned disturbance information
(in the case of eccectricity)
Disturbance information
Value converted into voltage or the like
Outer periphery side
B
Time
A:Recommended position of jump starting
Innerr periphery side
Disk rotation cycle
Jump applying pulse
T1
Jump starting (jump from inner periphery to outer periphery)
(a)
Disturbance information
-A
-B
Time
Jump applying pulse
T2
Jump starting (jump from outer periphery to inner periphery)
(b)

FIG. 18

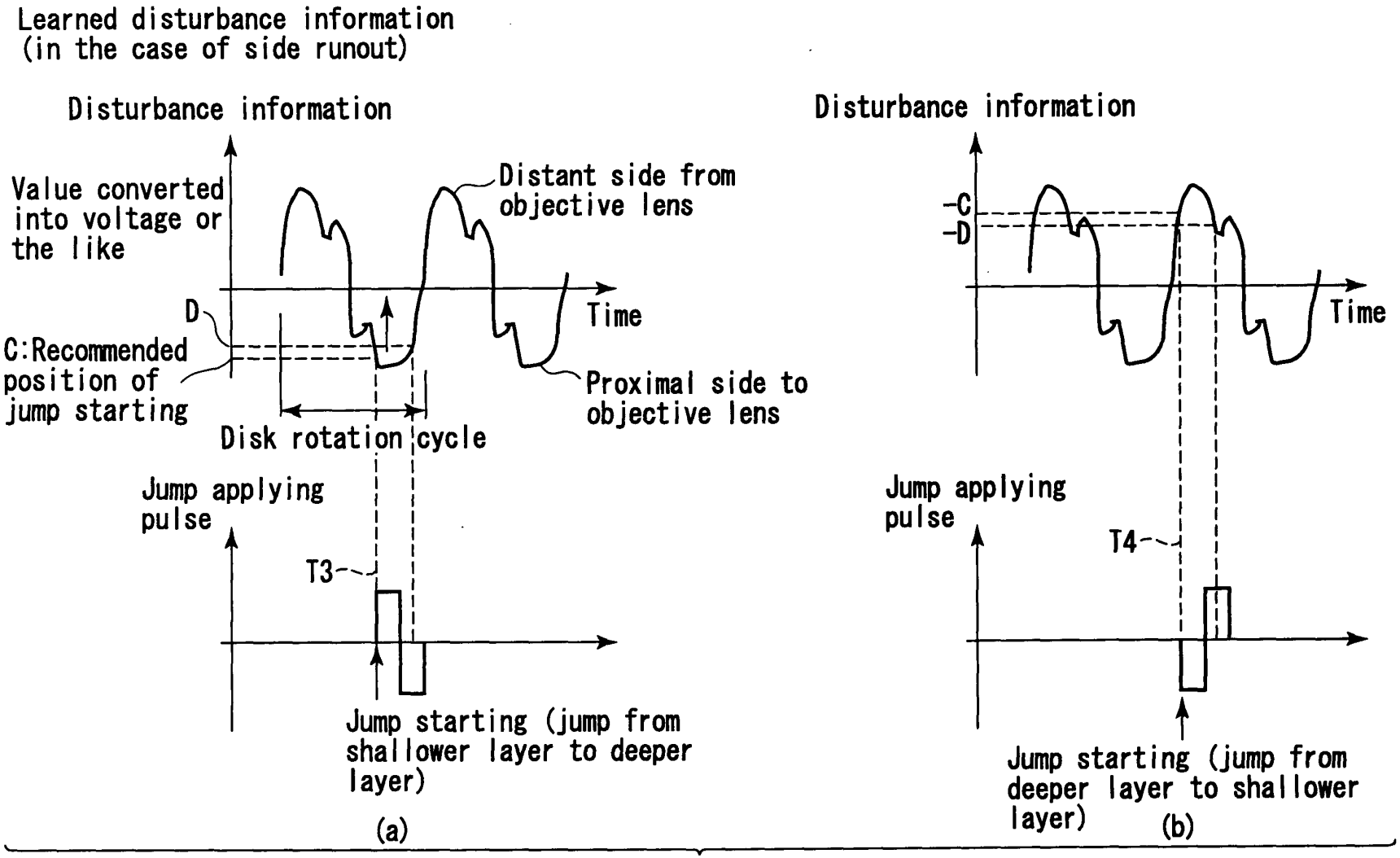
Learned disturbance information
(in the case of side runout)
Disturbance information
Value converted into voltage or the like
Distant side from objective lens
D
Time
C:Recommended position of jump starting
Proximal side to objective lens
Disk rotation cycle
Jump applying pulse
T3
Jump starting (jump from shallower layer to deeper layer)
(a)
Disturbance information
-C
-D
Time
Jump applying pulse
T4
Jump starting (jump from deeper layer to shallower layer)
(b)

FIG. 19

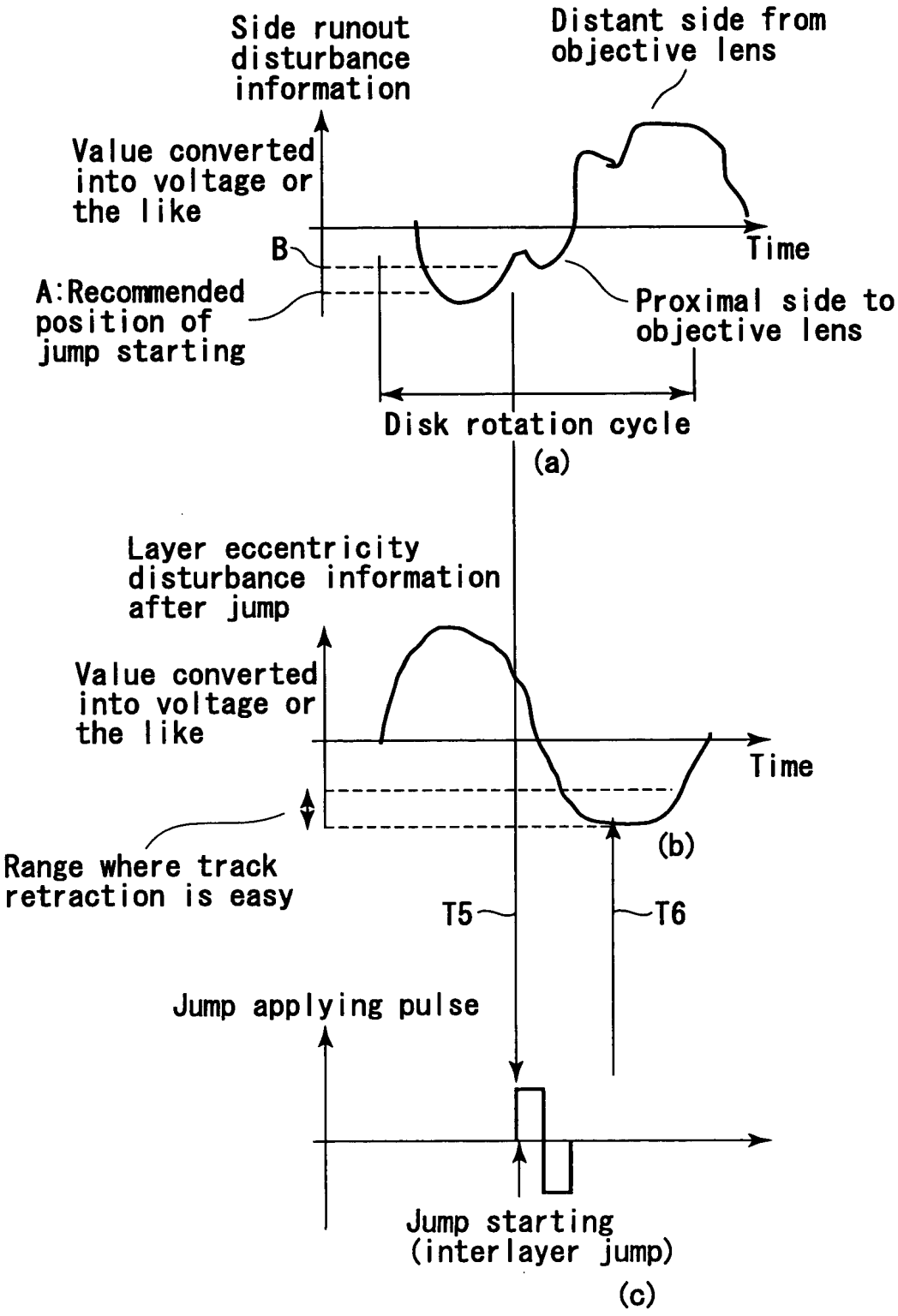
Side runout disturbance information
Distant side from objective lens
Value converted into voltage or the like
Time
B
A:Recommended position of jump starting
Proximal side to objective lens
Disk rotation cycle
(a)
Layer eccentricity disturbance information after jump
Value converted into voltage or the like
Time
Range where track retraction is easy
(b)
T5
T6
Jump applying pulse
Jump starting (interlayer jump)
(c)

FIG. 20

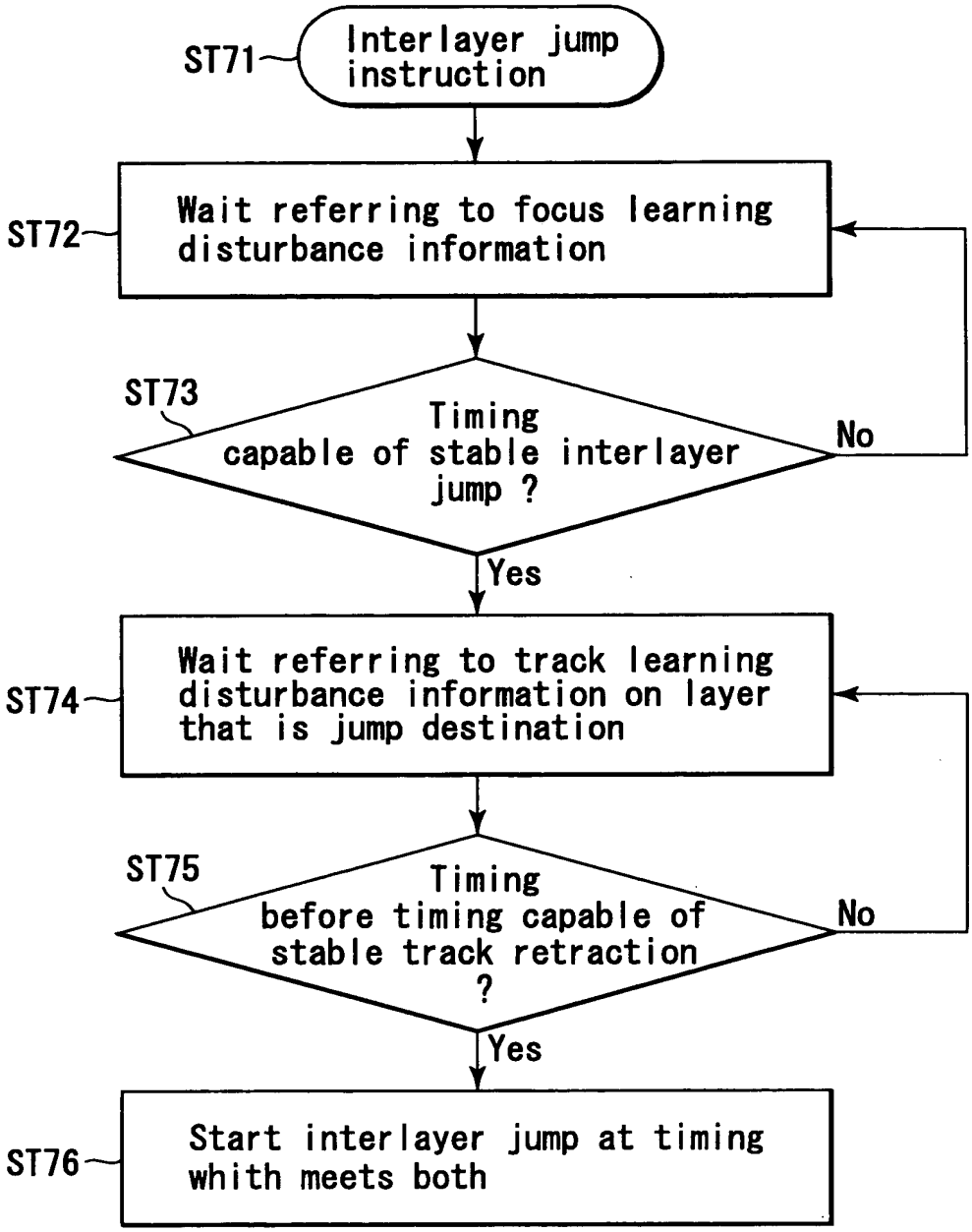
ST71
Interlayer jump instruction
ST72
Wait referring to focus learning disturbance information
ST73
Timing capable of stable interlayer jump ?
No
Yes
ST74
Wait referring to track learning disturbance information on layer that is jump destination
ST75
Timing before timing capable of stable track retraction ?
No
Yes
ST76
Start interlayer jump at timing whith meets both

FIG. 21

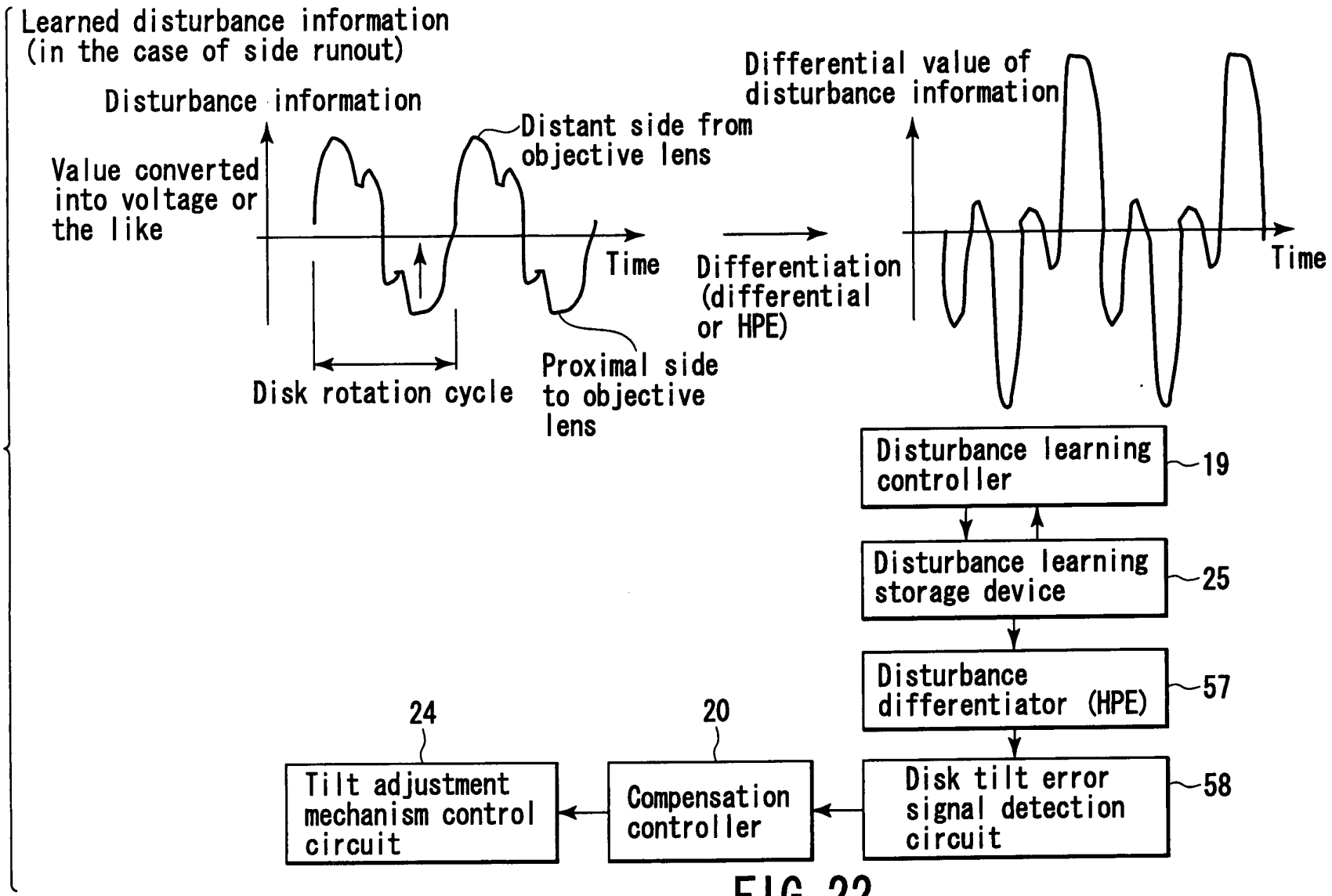
Learned disturbance information
(in the case of side runout)
Disturbance information
Value converted into voltage or the like
Distant side from objective lens
Time
Disk rotation cycle
Proximal side to objective lens
Differentiation (differential or HPE)
Differential value of disturbance information
Time
Disturbance learning controller
19
Disturbance learning storage device
25
Disturbance differentiator (HPE)
57
Disk tilt error signal detection circuit
58
20
Compensation controller
24
Tilt adjustment mechanism control circuit

FIG. 22

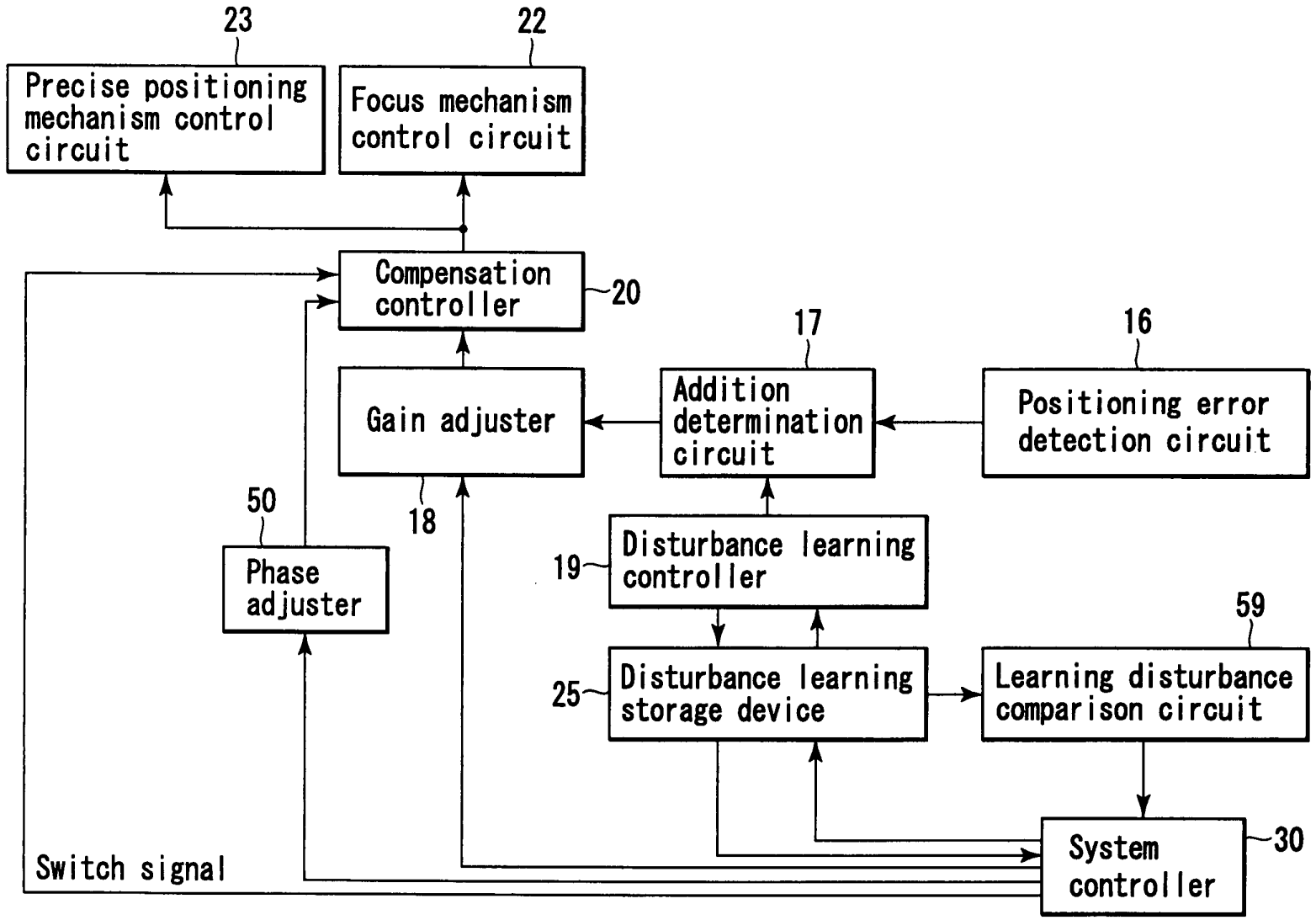
23
22
Precise positioning mechanism control circuit
Focus mechanism control circuit
Compensation controller
20
17
16
Gain adjuster
Addition determination circuit
Positioning error detection circuit
50
18
Phase adjuster
19
Disturbance learning controller
59
25
Disturbance learning storage device
Learning disturbance comparison circuit
System controller
30
Switch signal

FIG. 23

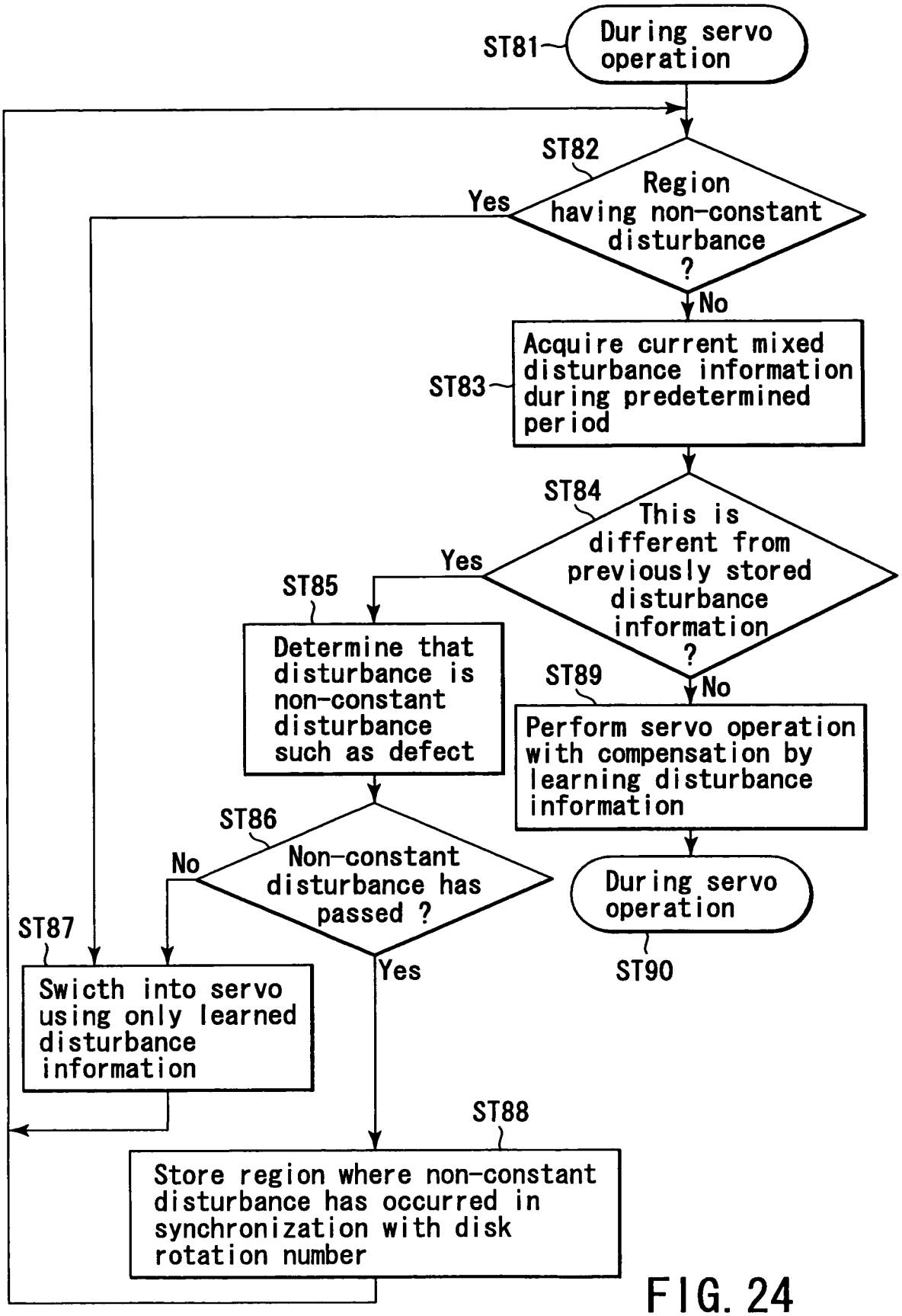
ST81
During servo operation
ST82
Region having non-constant disturbance ?
Yes
No
ST83
Acquire current mixed disturbance information during predetermined period
ST84
This is different from previously stored disturbance information ?
Yes
No
ST85
Determine that disturbance is non-constant disturbance such as defect
ST89
Perform servo operation with compensation by learning disturbance information
ST86
Non-constant disturbance has passed ?
No
Yes
During servo operation
ST90
ST87
Swicth into servo using only learned disturbance information
ST88
Store region where non-constant disturbance has occurred in synchronization with disk rotation number

FIG. 24

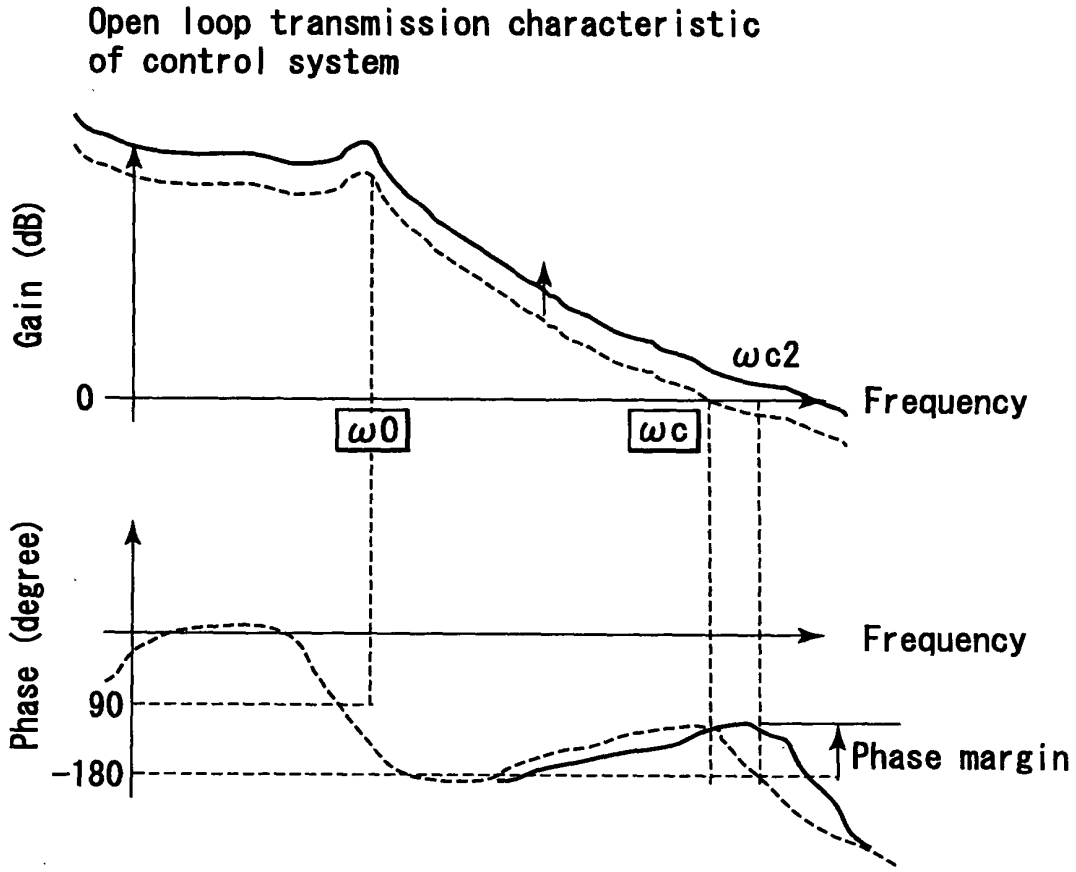
Open loop transmission characteristic
of control system
Gain (dB)
0
ωc2
Frequency
ω0
ωc
Phase (degree)
Frequency
90
-180
Phase margin

FIG. 25